Eastern Wind Integration and Transmission Study

Presentation to FERC

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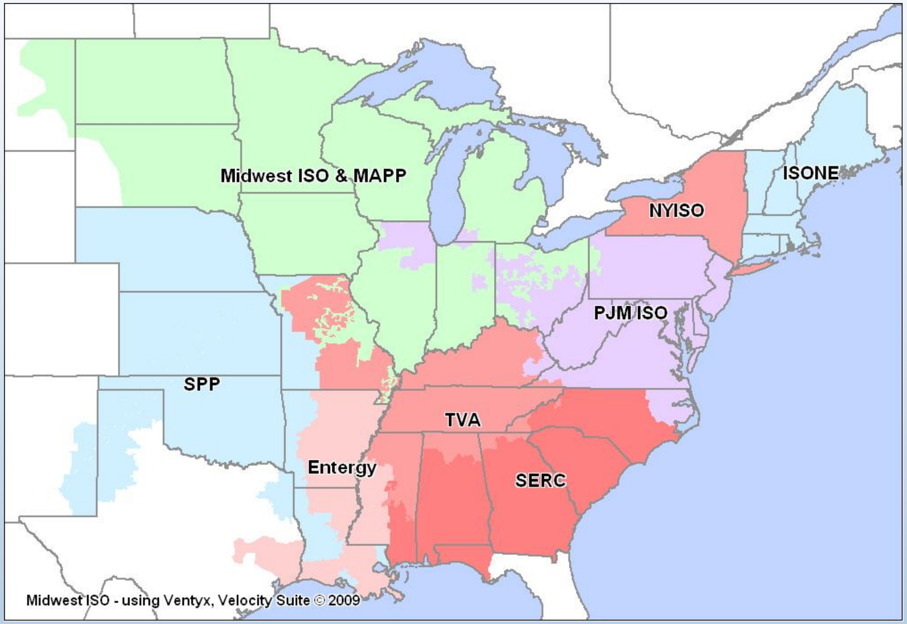
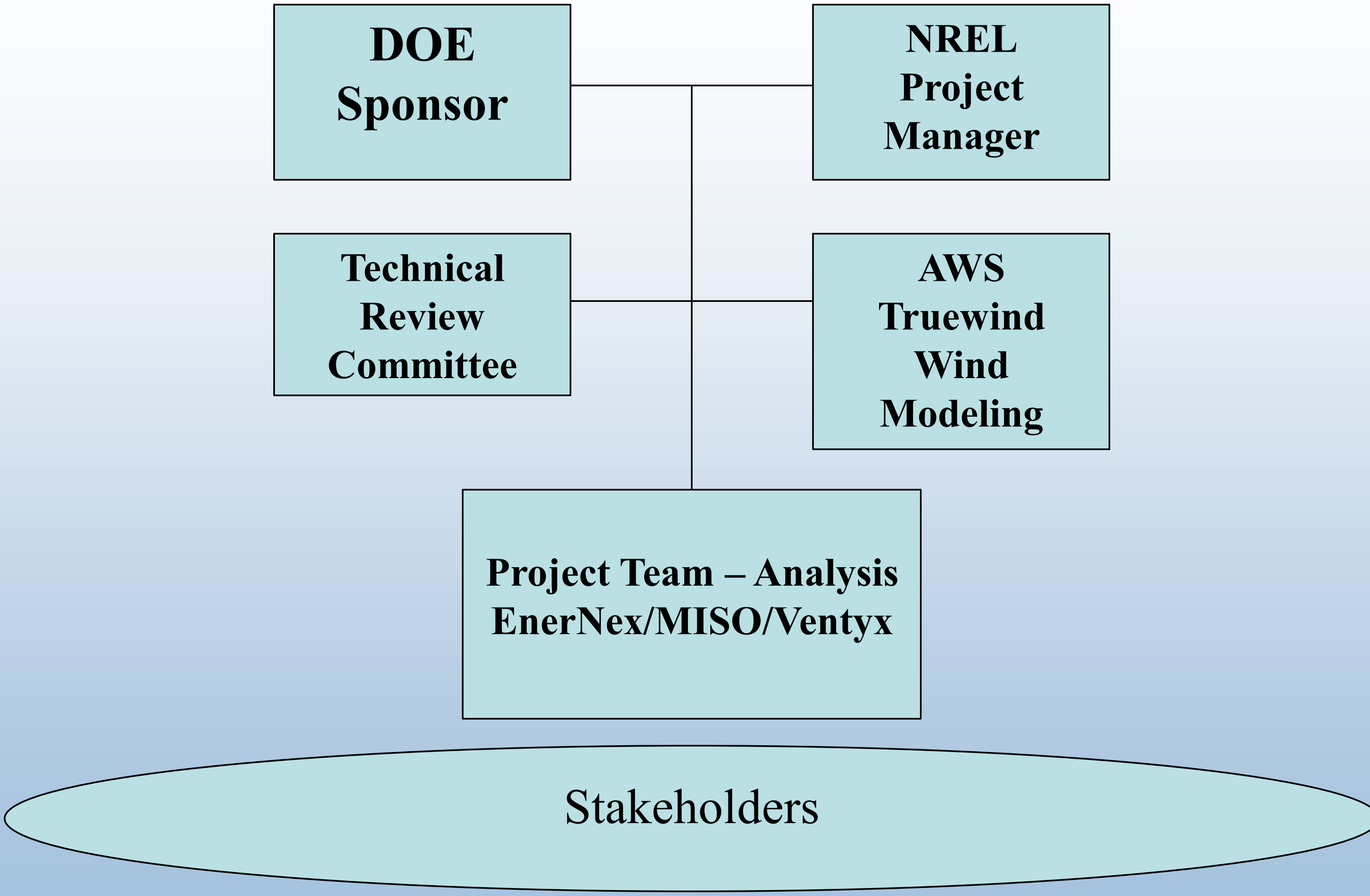
National Renewable Energy Lab

What is Needed to Integrate 20% Wind in the Eastern Interconnect?

- Evaluate the power system operating impacts and transmission associated with increasing wind capacity to 20% and 30%
    - Impacts include operating due to variability and uncertainty of wind; reliability
- Build upon prior wind integration studies and related technical work;
- Coordinate with current regional power system study work;
- Produce meaningful, broadly supported results
    - Technical Review Committee



EWITS Study Organization



Technical Review Committee

- Includes representation from the following organizations

New York Independent System Operator (NYISO) **Xcel Energy** **Southern Company** **PJM Interconnection** **Southwest Power Pool(SPP)** **U.S. Department of Energy** **Midwest ISO (MISO)** **Michigan Public Service Commission** **Area Power Pool (MAPP)** **American Wind Energy Association (AWEA)**	**Federal Energy Regulatory Commission (FERC) – observer status** **North American Electric Reliability Corporation (NERC)** **CapX 2020 (Great River Energy)** **Windlogics** **National Renewable Energy Lab** **General Electric (GE)** **Regulatory Assistance Project** **University College Dublin** **Organization of MISO States (Wisconsin Public Service Commission)**

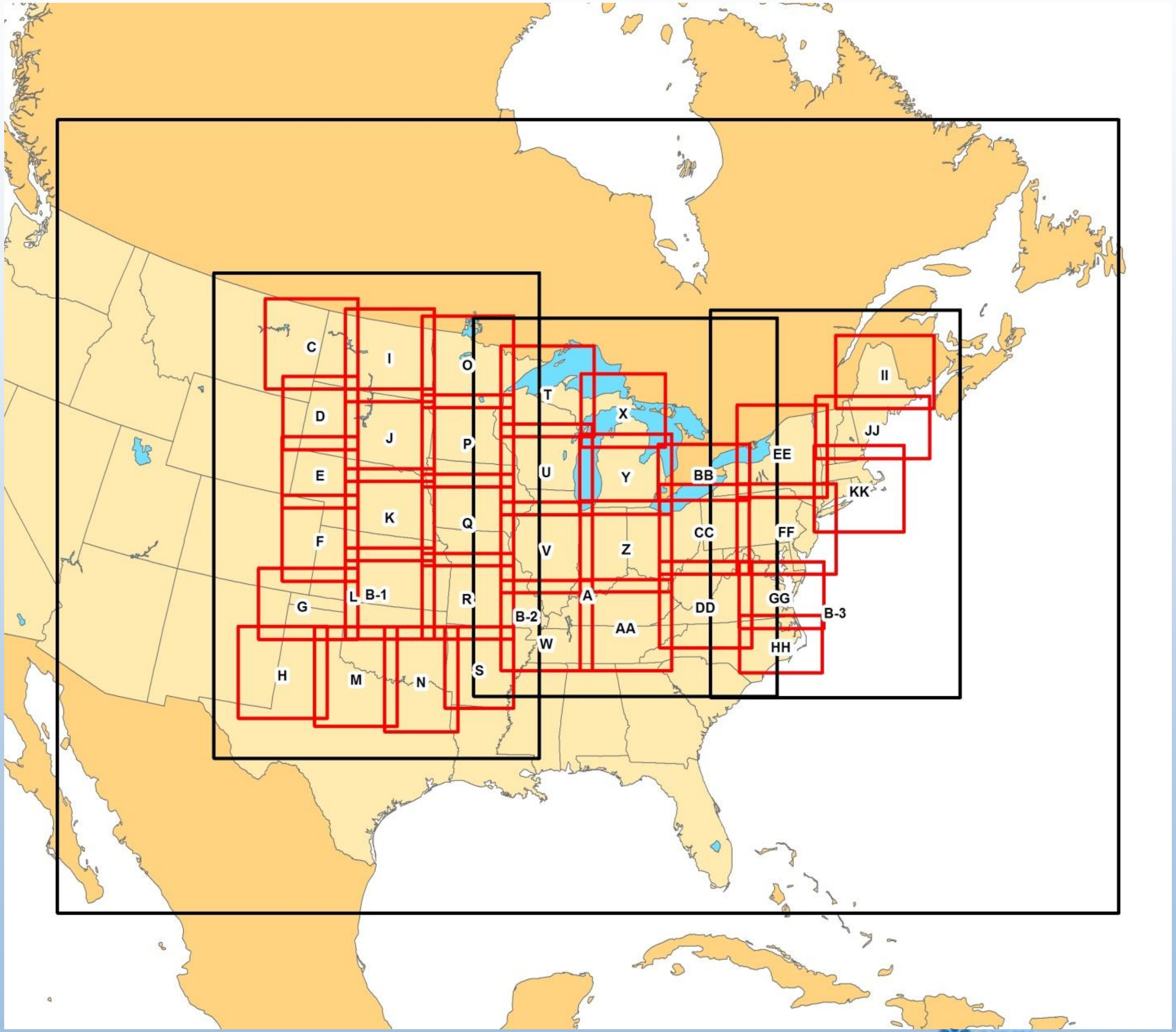
The Technical Work Conducted in EWITS Yielded Detailed Quantitative Information on

- Wind generation required to produce 20% of the projected electric energy demand over the U.S. portion of the Eastern Interconnection in 2024
- Transmission concepts for delivering energy economically for each scenario
- Economic sensitivity simulations of the hourly operation of the power system defined by a wind generation forecast scenario and the associated transmission overlay
- The contribution made by wind generation to resource adequacy and planning capacity margin

Key Tasks- Eastern Wind Integration & Transmission Study

- Mesoscale modeling and Siting
  - Develop high quality wind resource data sets for the wind integration study area
  - Develop wind power plant outputs
  - Identify wind sites and develop siting scenarios
- Transmission Study – Develop transmission concepts for different wind scenarios
- Integration Study
  - Evaluate Operating Impacts
  - Evaluate Reliability Impacts
  - Compare Scenario Costs

Mesoscale Grids



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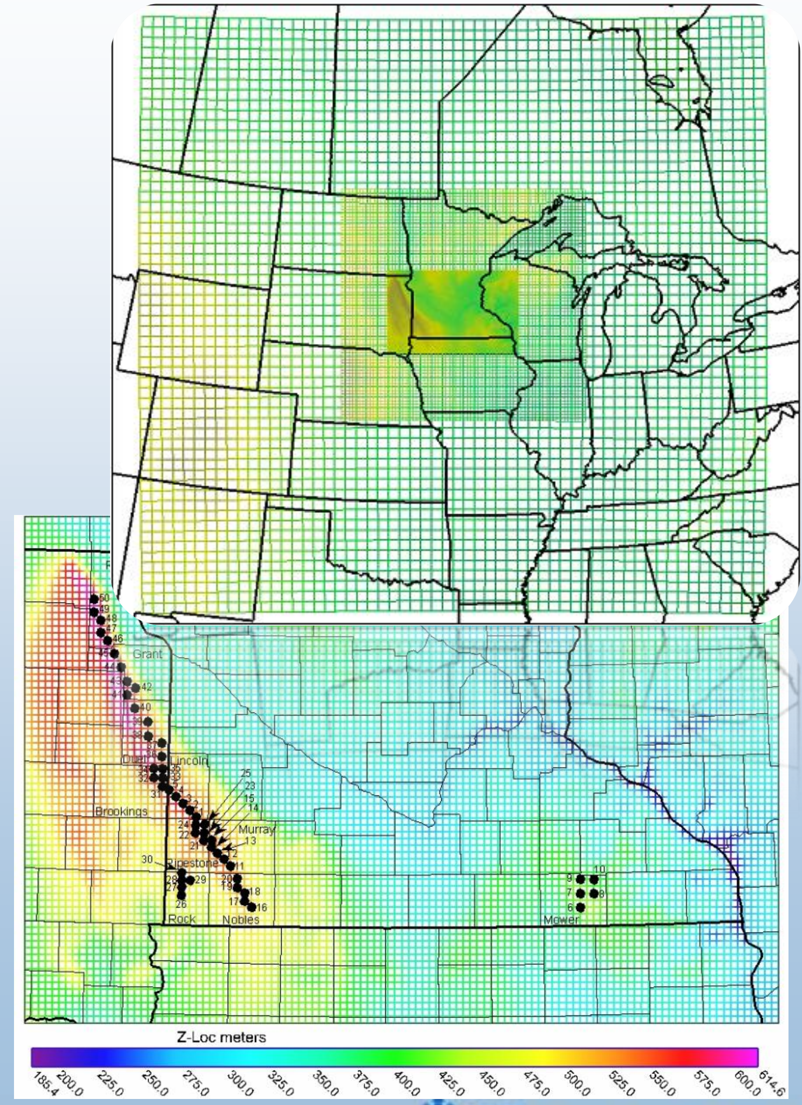
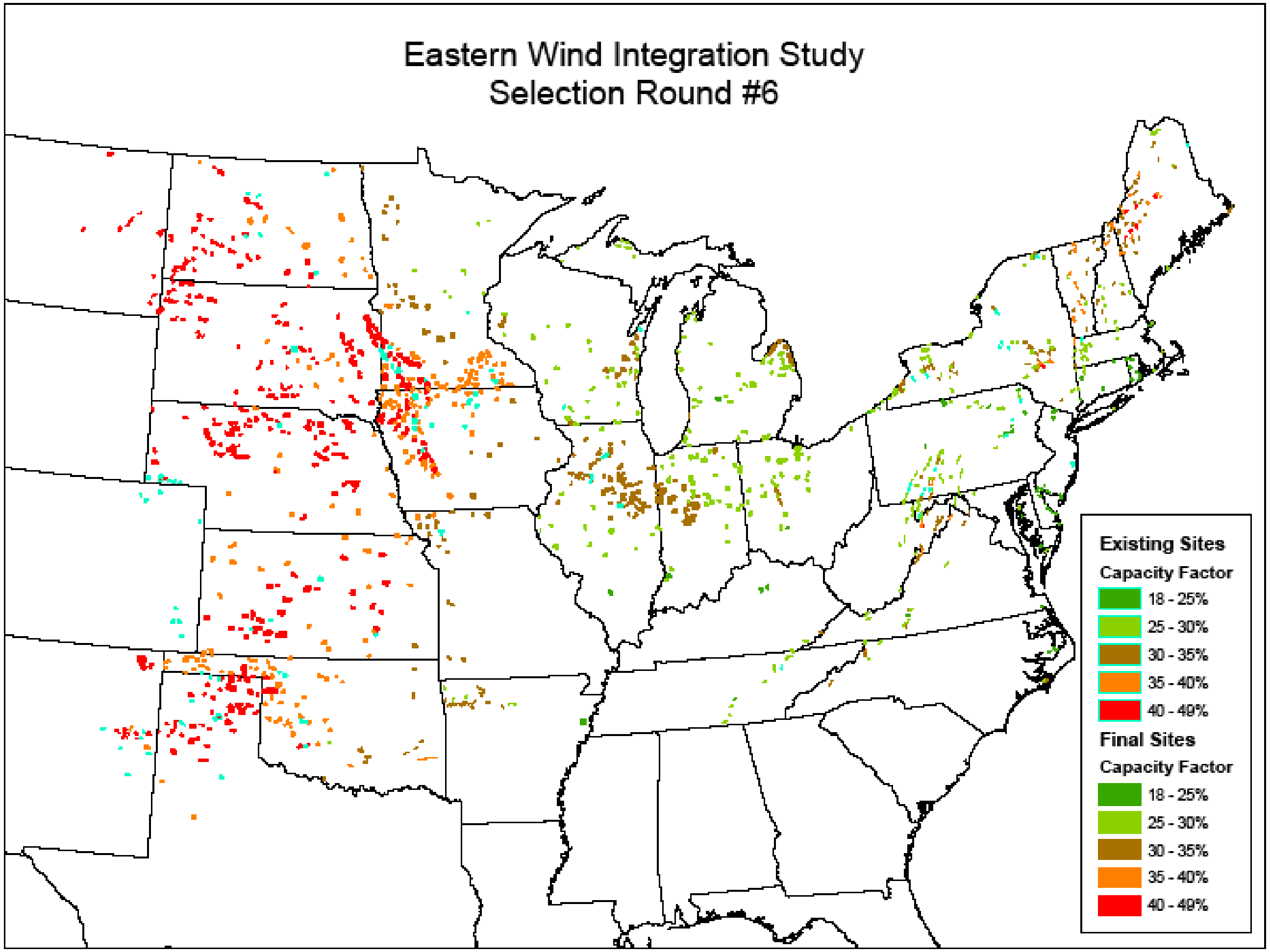
Wind Plant Modeling Approach: "Re-creating" the Weather

- Use meteorological modeling to simulate weather for historical years
  - e.g. MM5 model used for weather forecasting
  - "zoom in" for both space and time (e.g. 5 min, 2 mi x 2 mi)
  - Use actual weather to guide simulation, nudge back to reality
- Save important weather variables at points of interest
  - Wind speed and direction @ hub height
  - Temperature
  - Pressure
- Convert time series of wind speed data to generation using turbine power curves

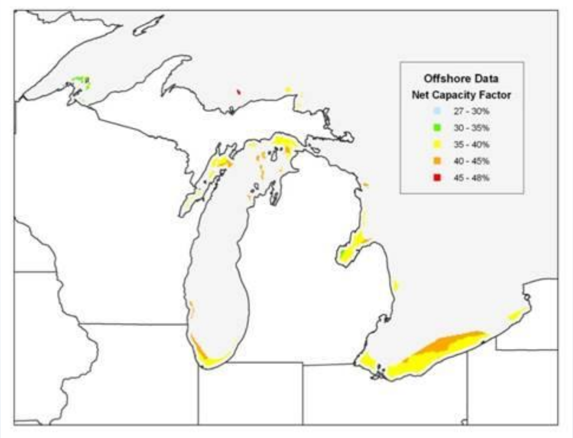


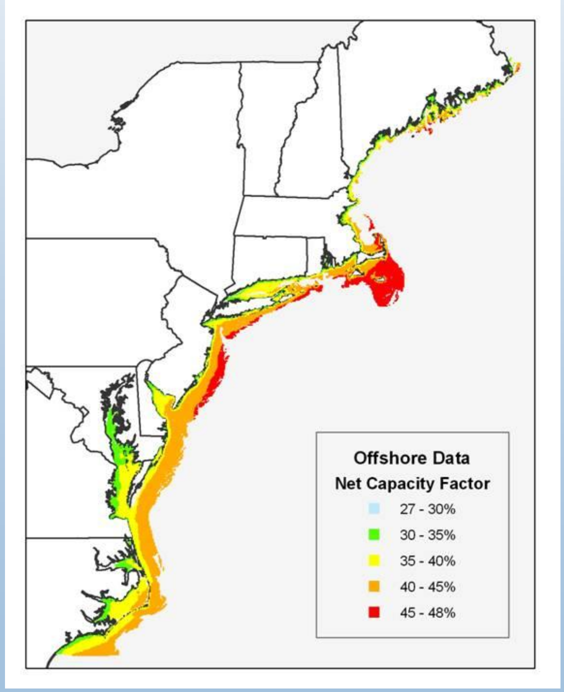
579 GWs of Wind Sites from Wind Site Selection process for EWITS



Offshore Wind

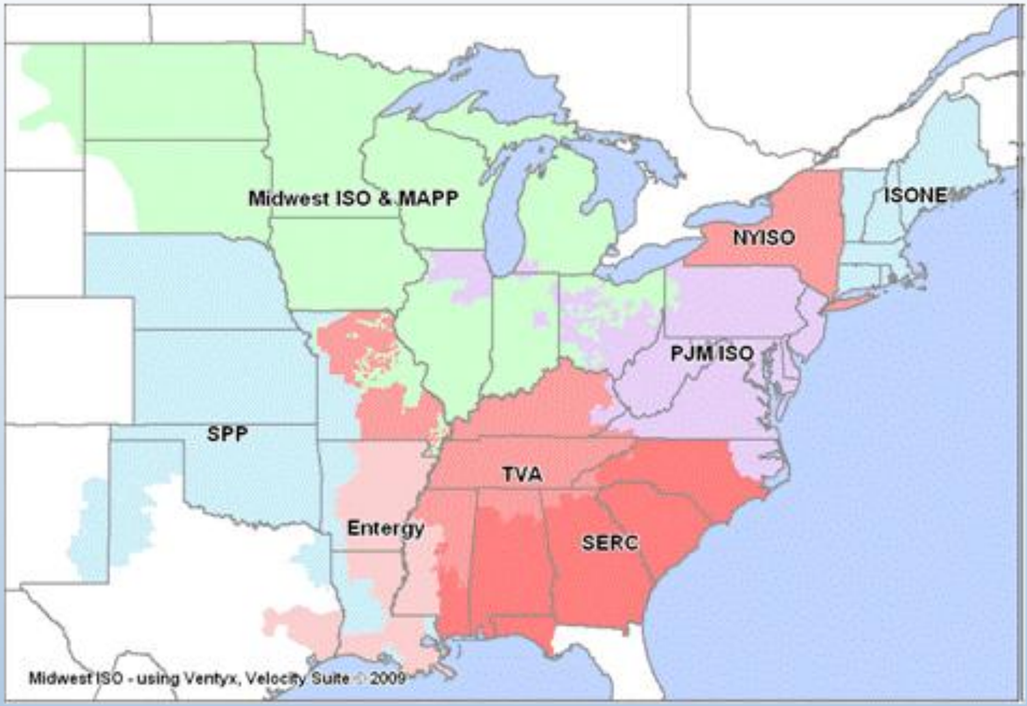
- Great resource
- Well correlated with load and close to load centers
- More expensive!



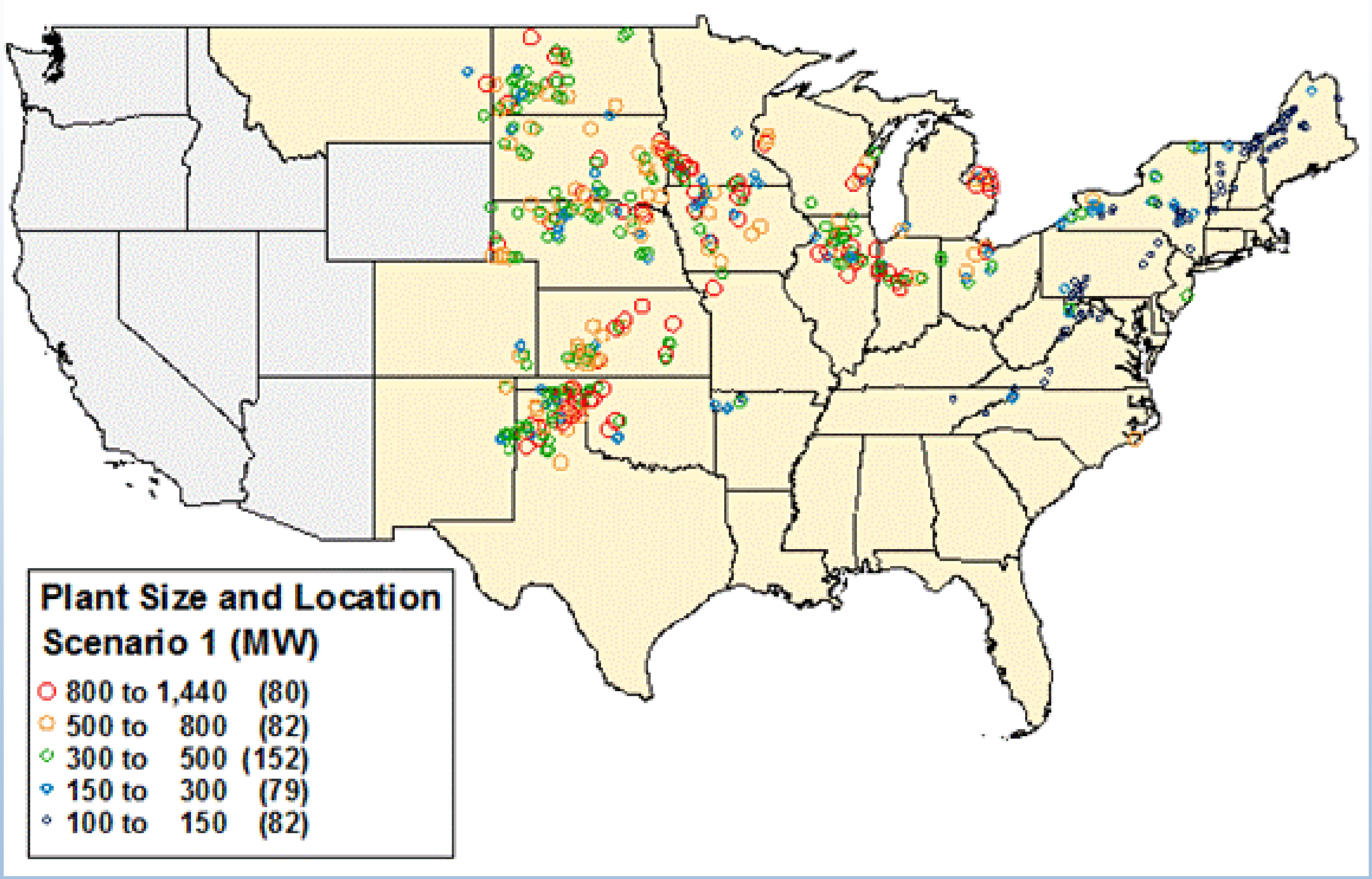


20% Wind Requires Some Regions to Supply More Based on Resource Availability

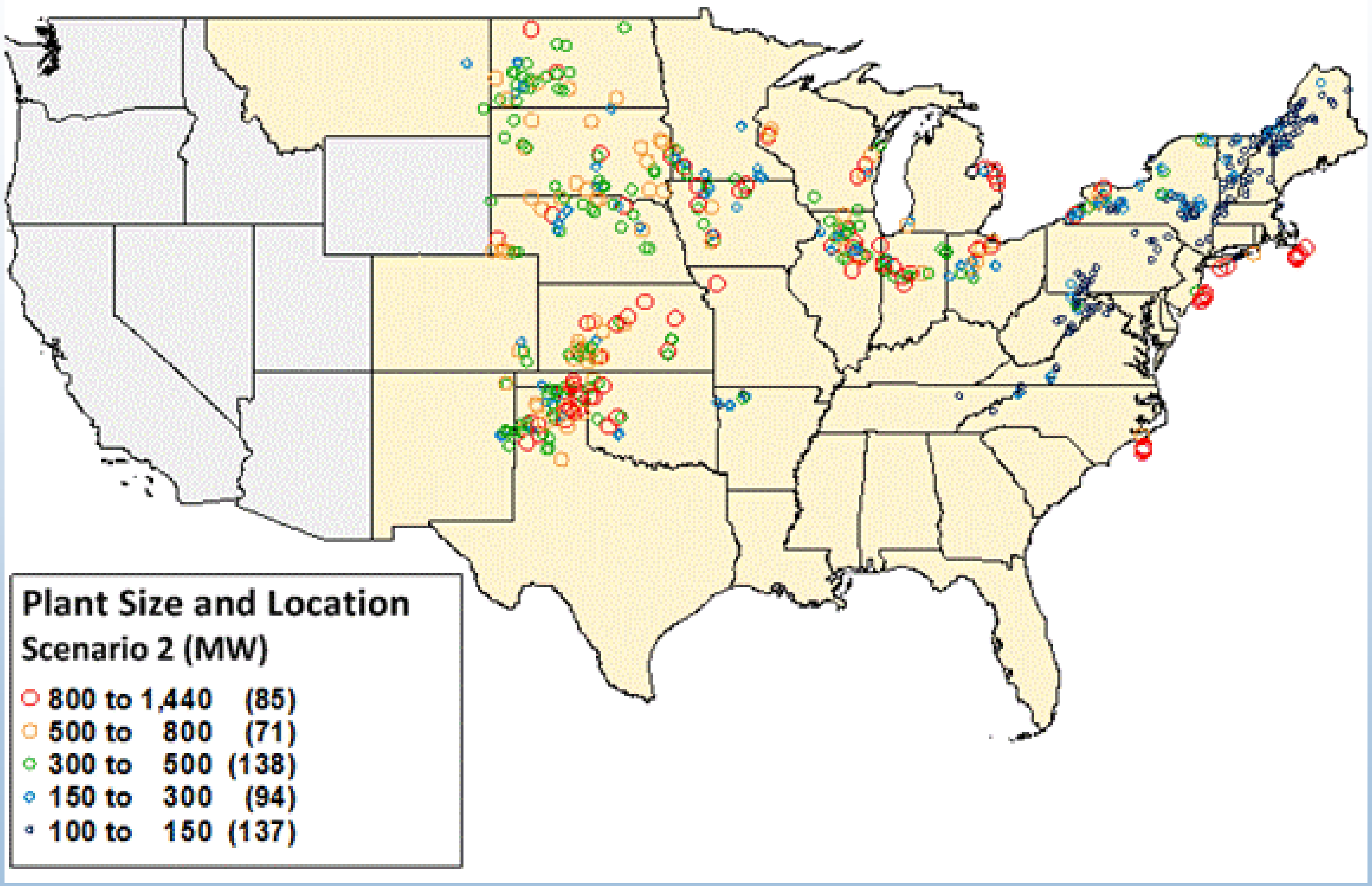
- Areas that meet 20% wind energy on a regional basis, by scenario
  - Scenario 1: Midwest ISO, MAPP, SPP
  - Scenario 2: Midwest ISO, MAPP, SPP, New England ISO (ISO-NE), New York ISO (NYISO)
  - Scenario 3: MAPP, SPP, PJM, ISO-NE, NYISO
  - Scenario 4: Midwest ISO, MAPP, SPP, PJM, ISO-NE, NYISO



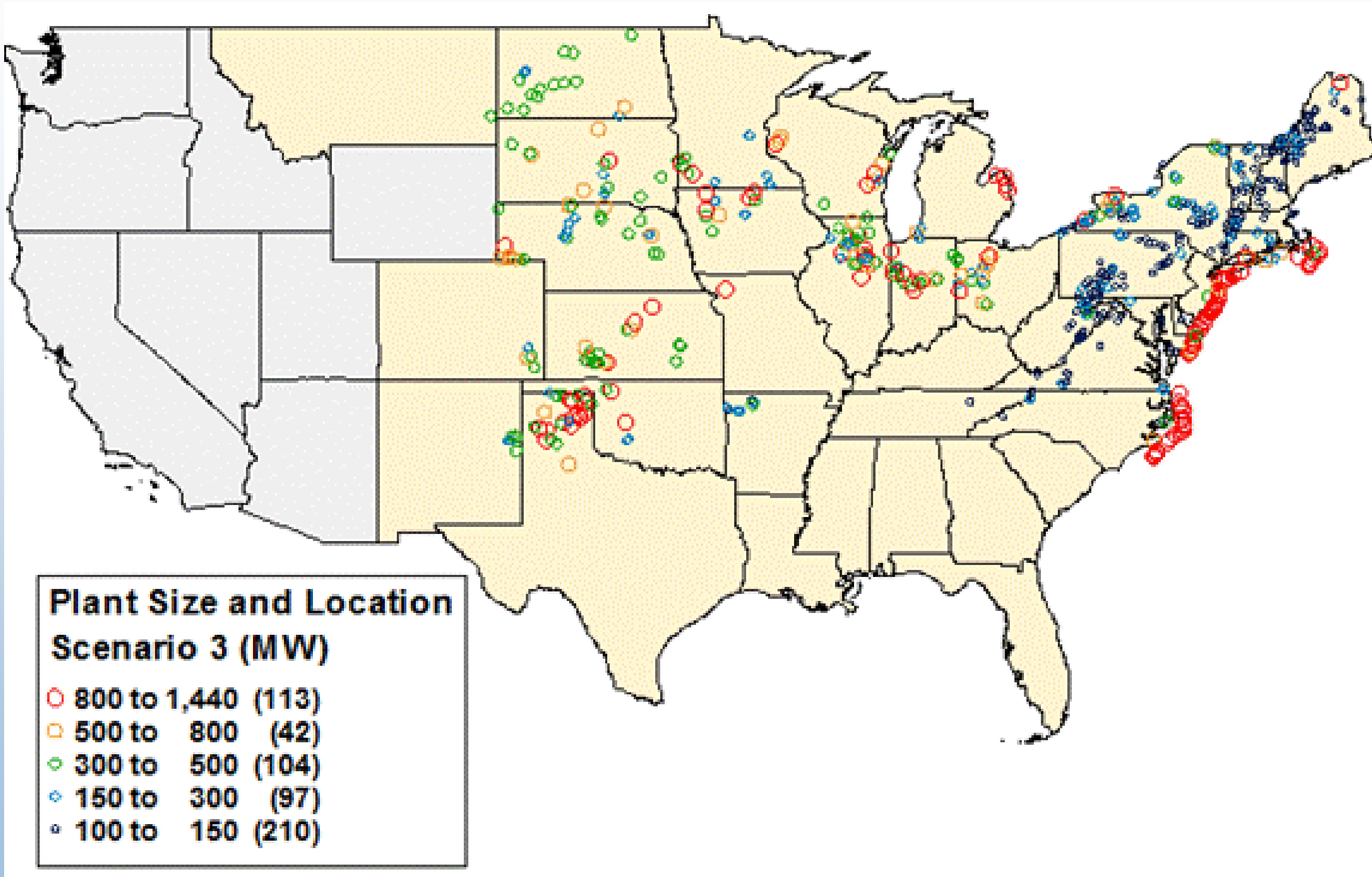
Scenario 1 – 20% "High Capacity Factor, On shore"



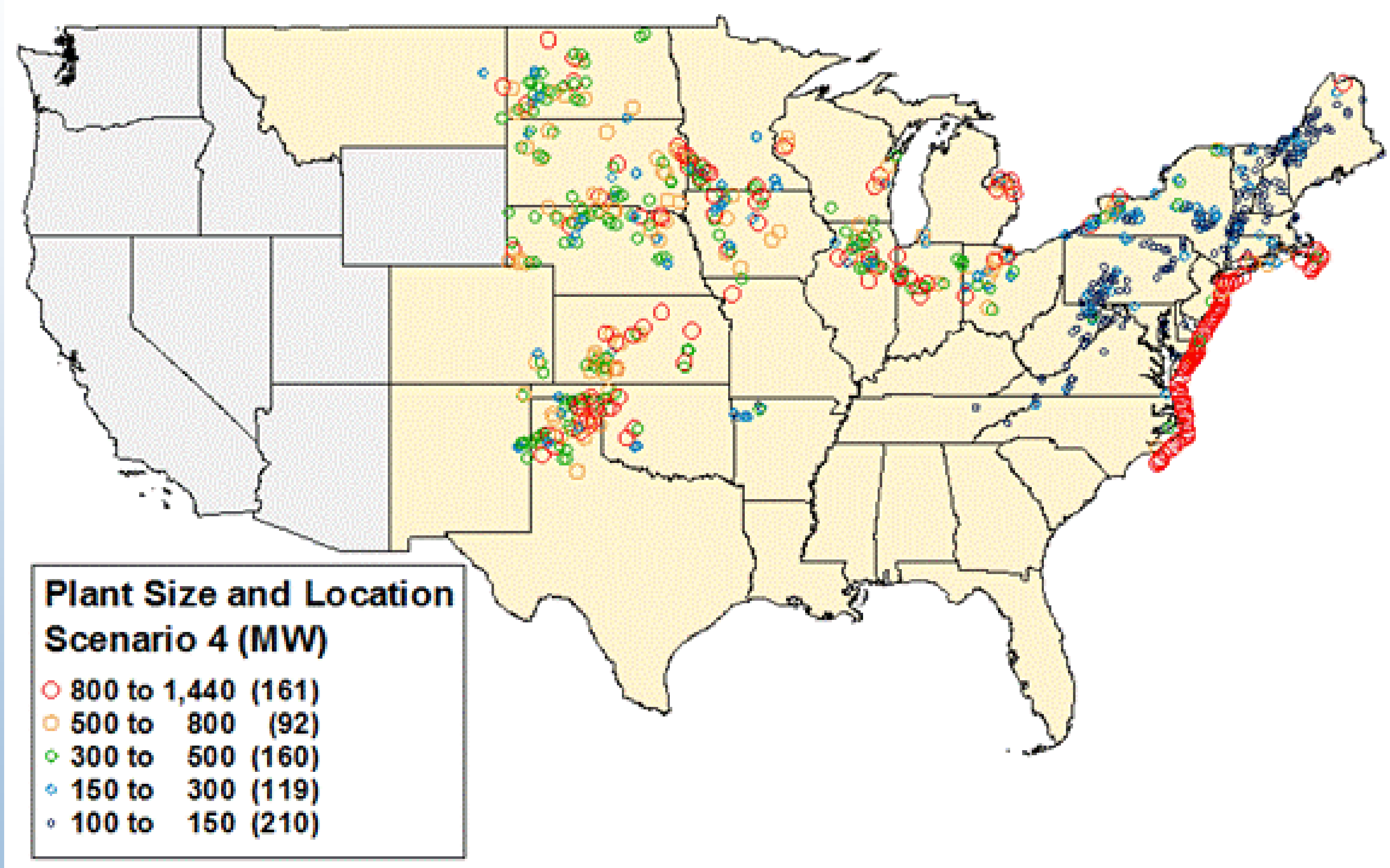
Scenario 2 - 20% "Hybrid with Offshore"



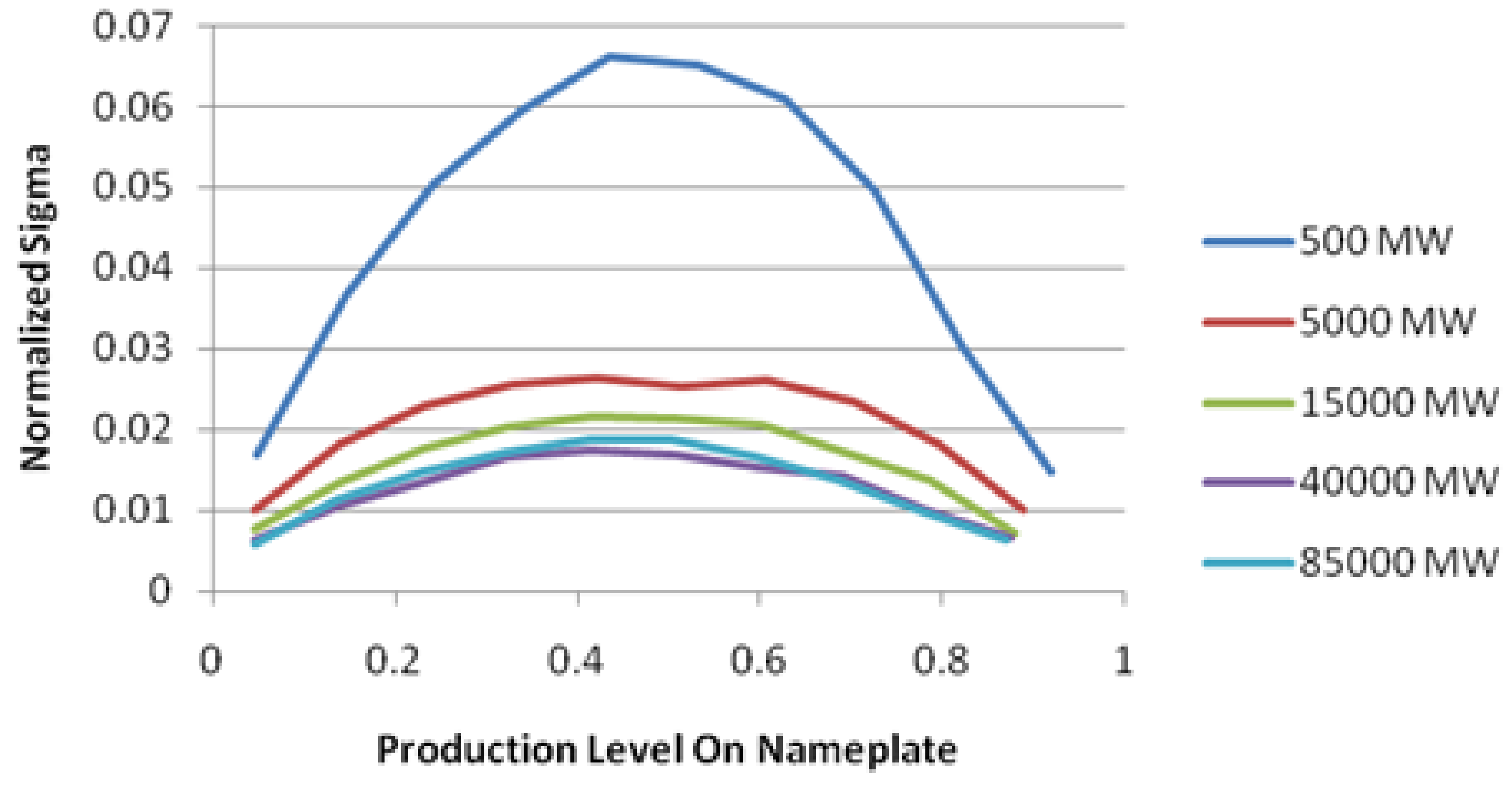
Scenario 3 - 20% “Local, with Aggressive Offshore”



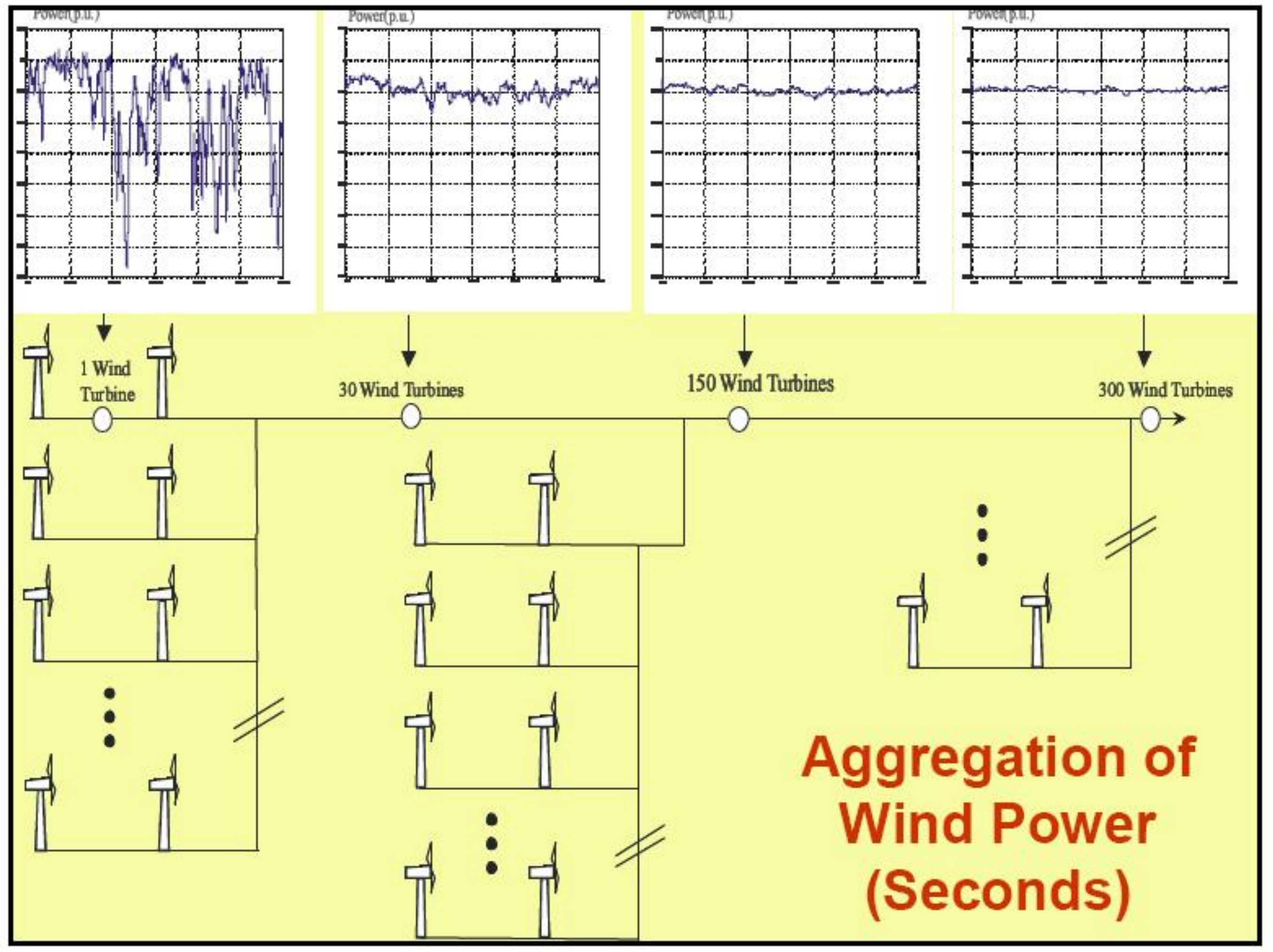
Scenario 4 - 30% “Aggressive On- and Off-Shore”



Geographic Diversity – 10-Minute Variability for Five Regions



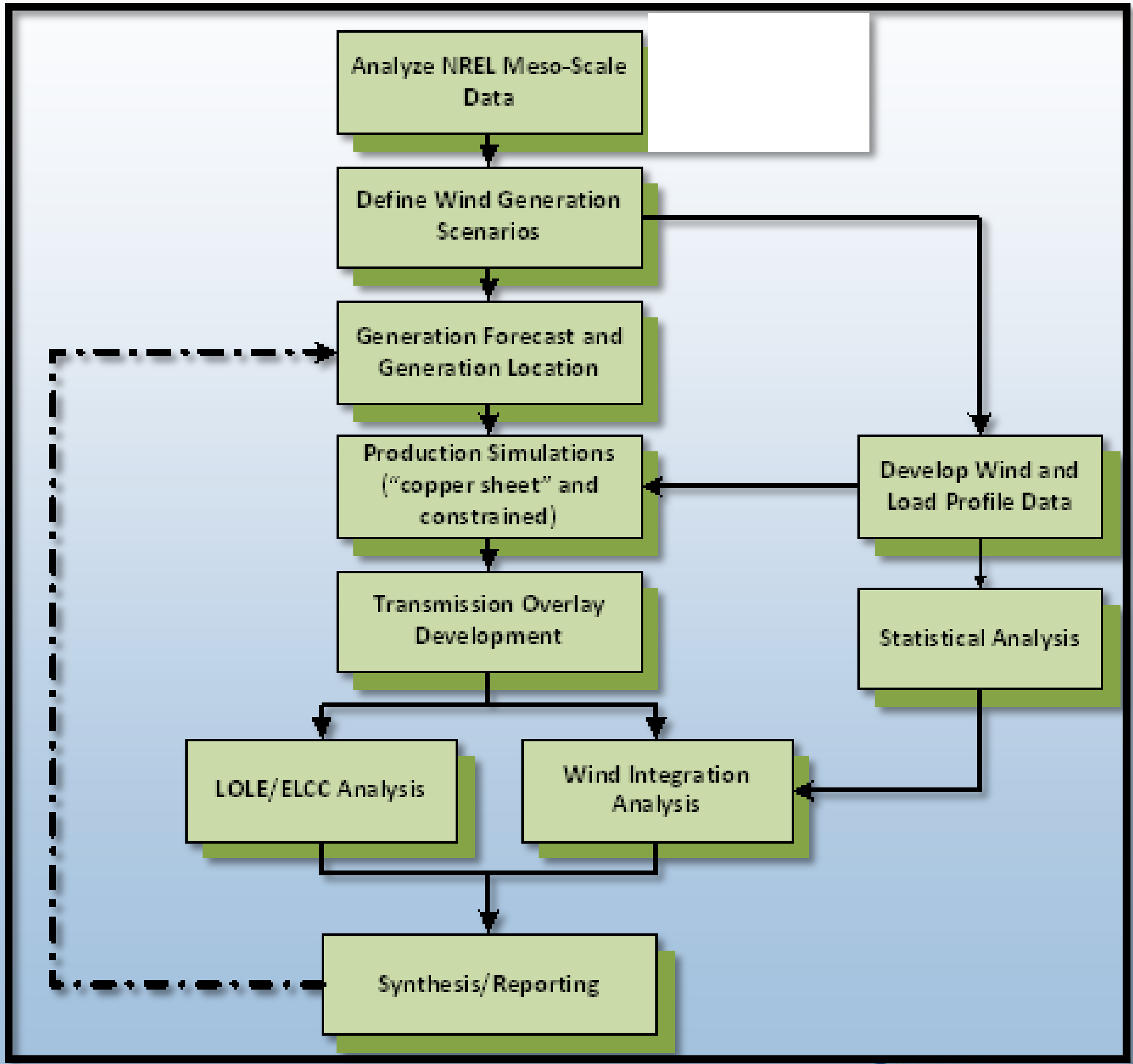
The Power of Aggregation



Methods & Assumptions

- 2024 wind scenario development
- Power system models for 2024
  - MISO Runs production cost model
- Developing Transmission Overlays
  - Build off some JCSP assumptions but includes different scenarios
- Evaluating operating impacts
- Evaluating reliability impacts

EWITS Methodology

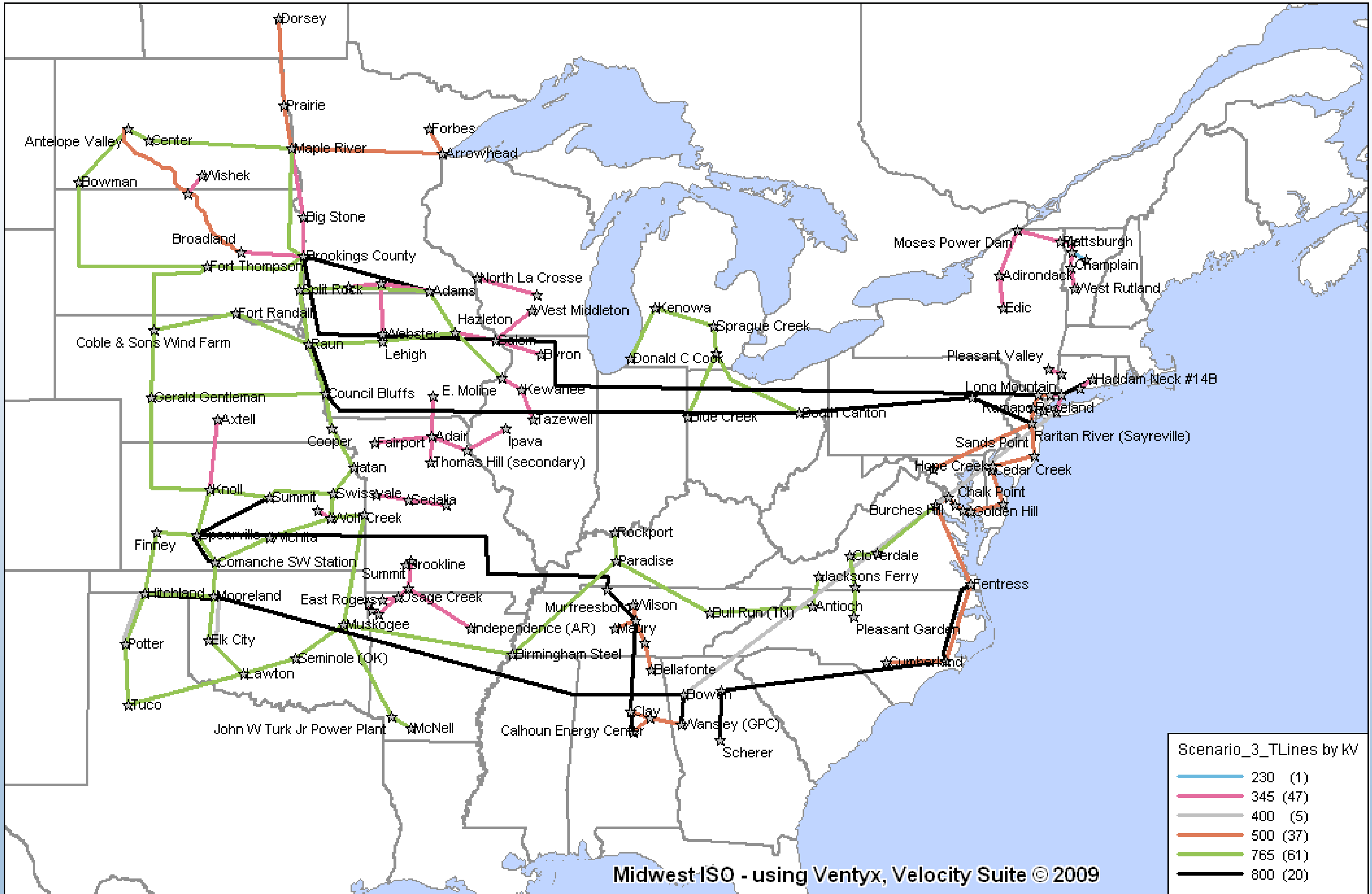


Transmission Requirements

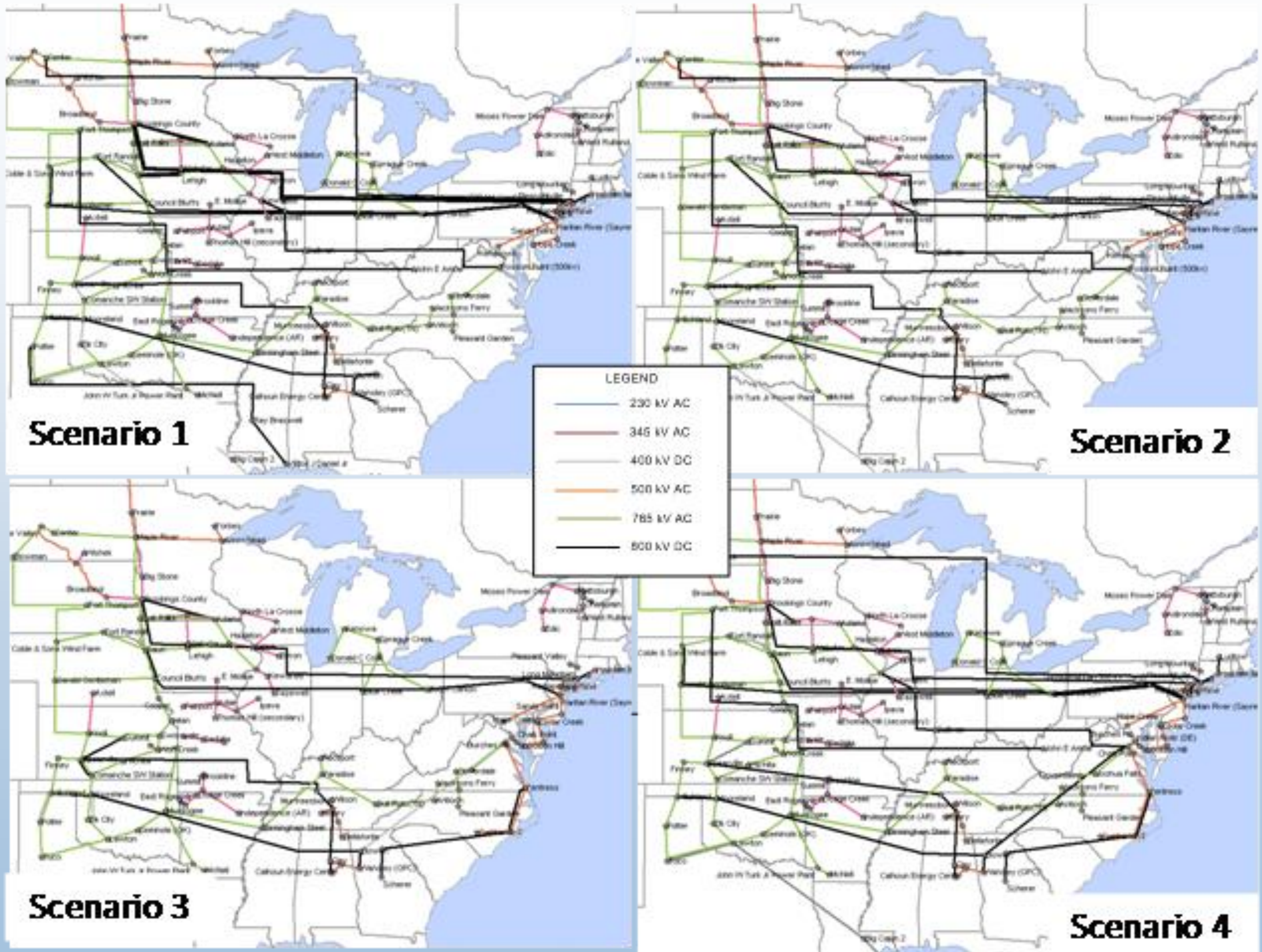
- High levels of new transmission are needed across the 4 scenarios
  - Some transmission elements are common to all overlays
- Reference case, 20% and 30% wind scenarios all require a significant transmission build out, otherwise they are not feasible
- Transmission reduces variability and provides capacity benefits in its own right, and enhances the reliability contribution of wind generation by a measureable and significant amount.
- The EHV DC transmission that constitutes a major portion of the overlays has additional benefits
- The conceptual transmission overlays consist of multiple 800kV HVDC and EHV AC lines

Transmission - Why are We Always Jumping Through Hoops

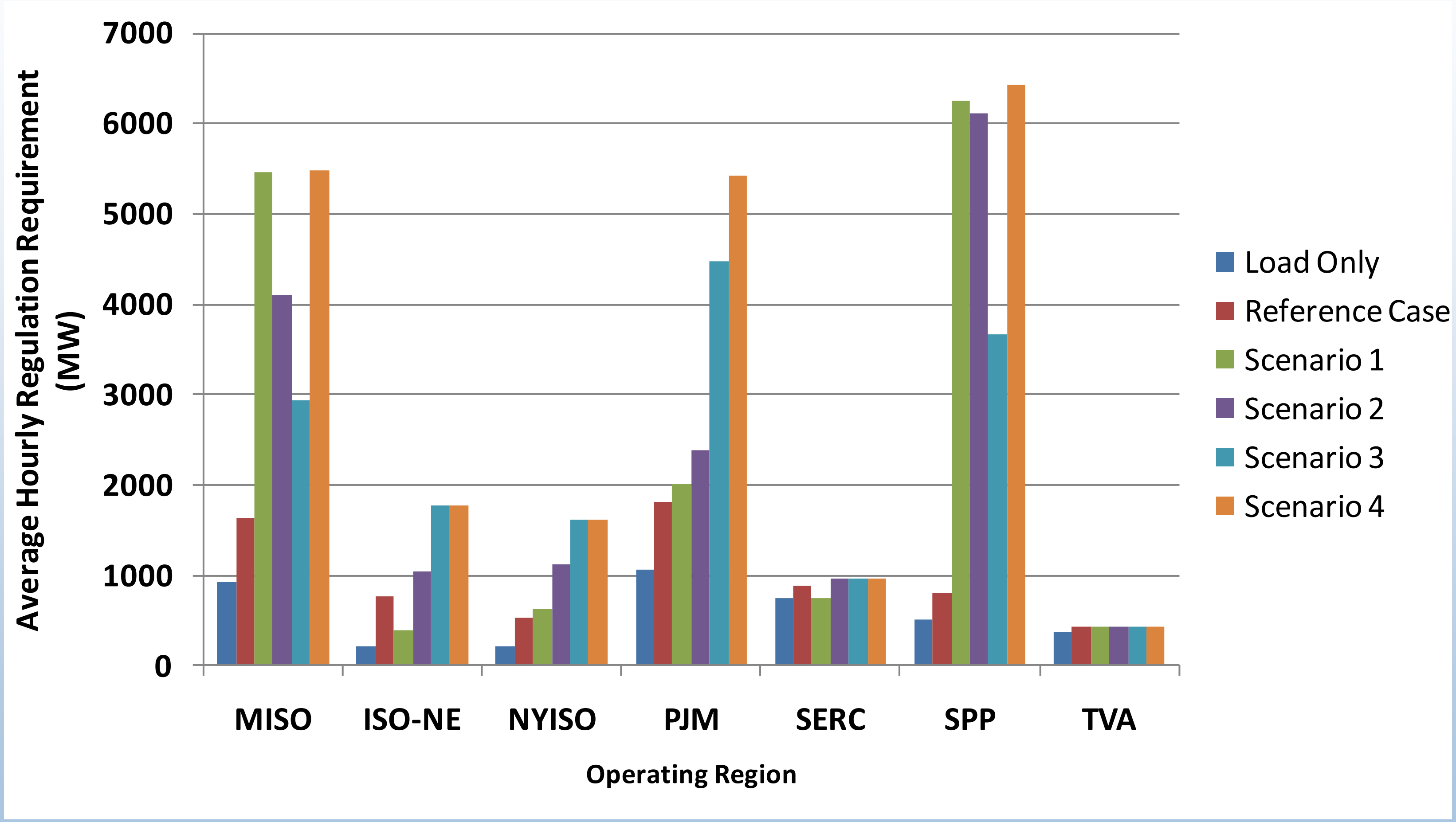
Transmission Overlay for Scenario 3



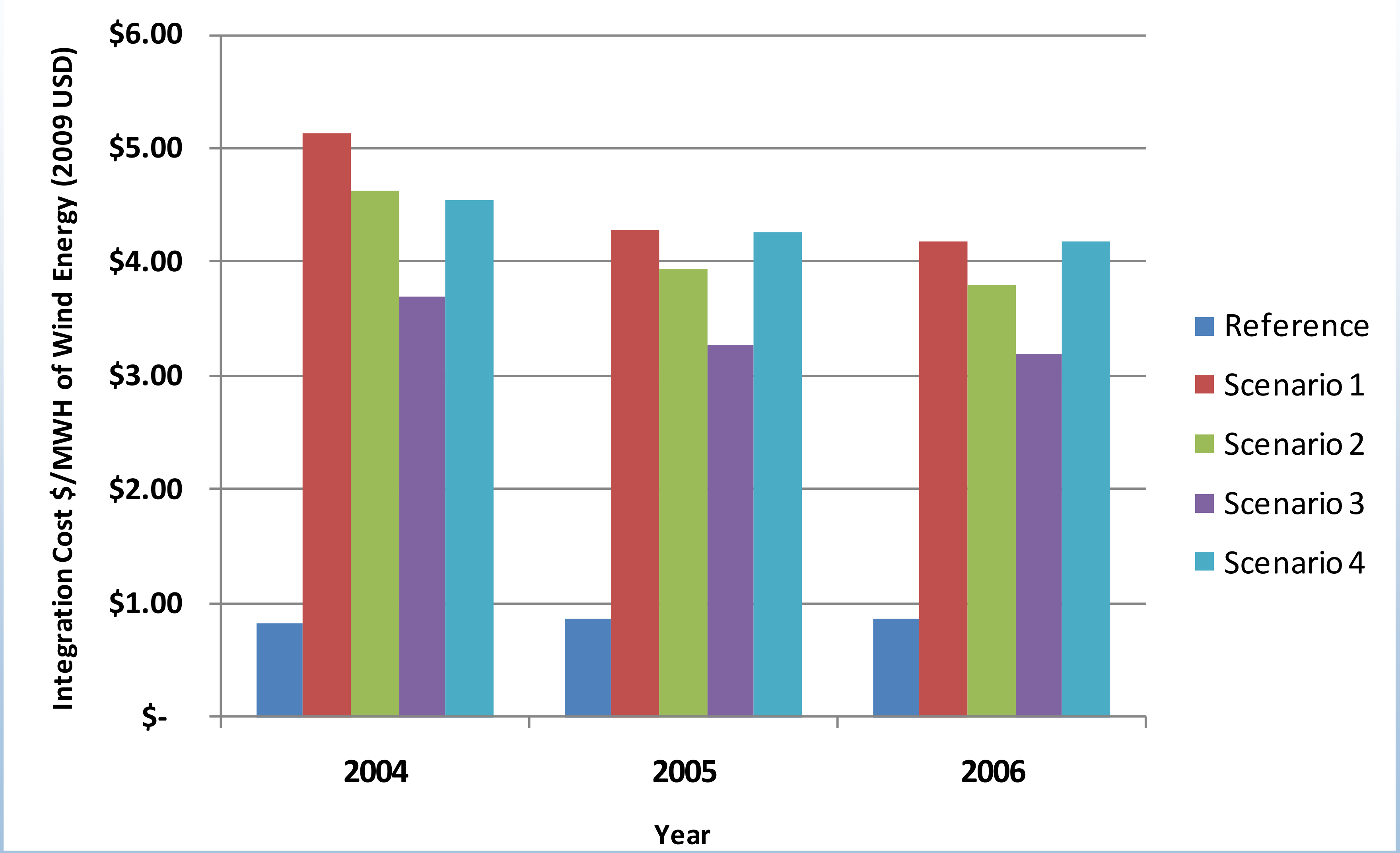
Conceptual Transmission Overlays



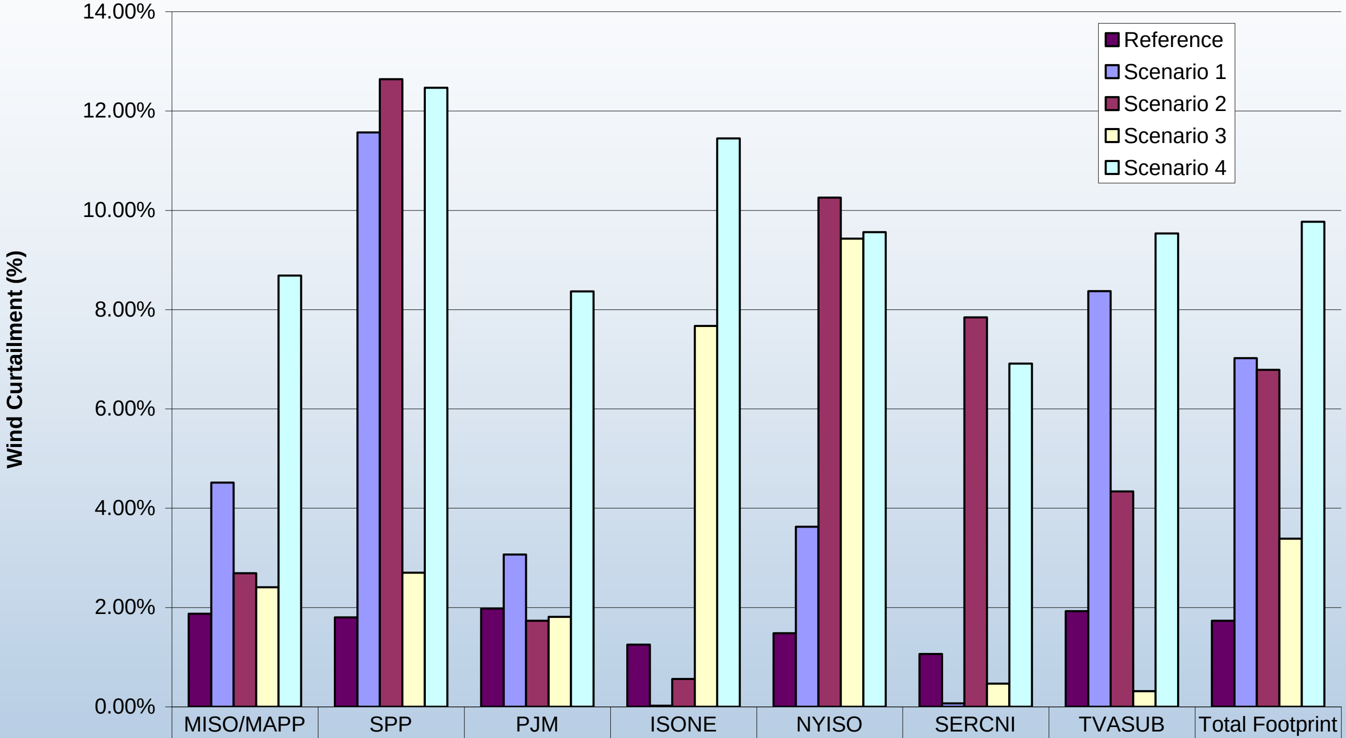
Additional Reserve Requirements by Region and Scenario



Wind Integration Costs



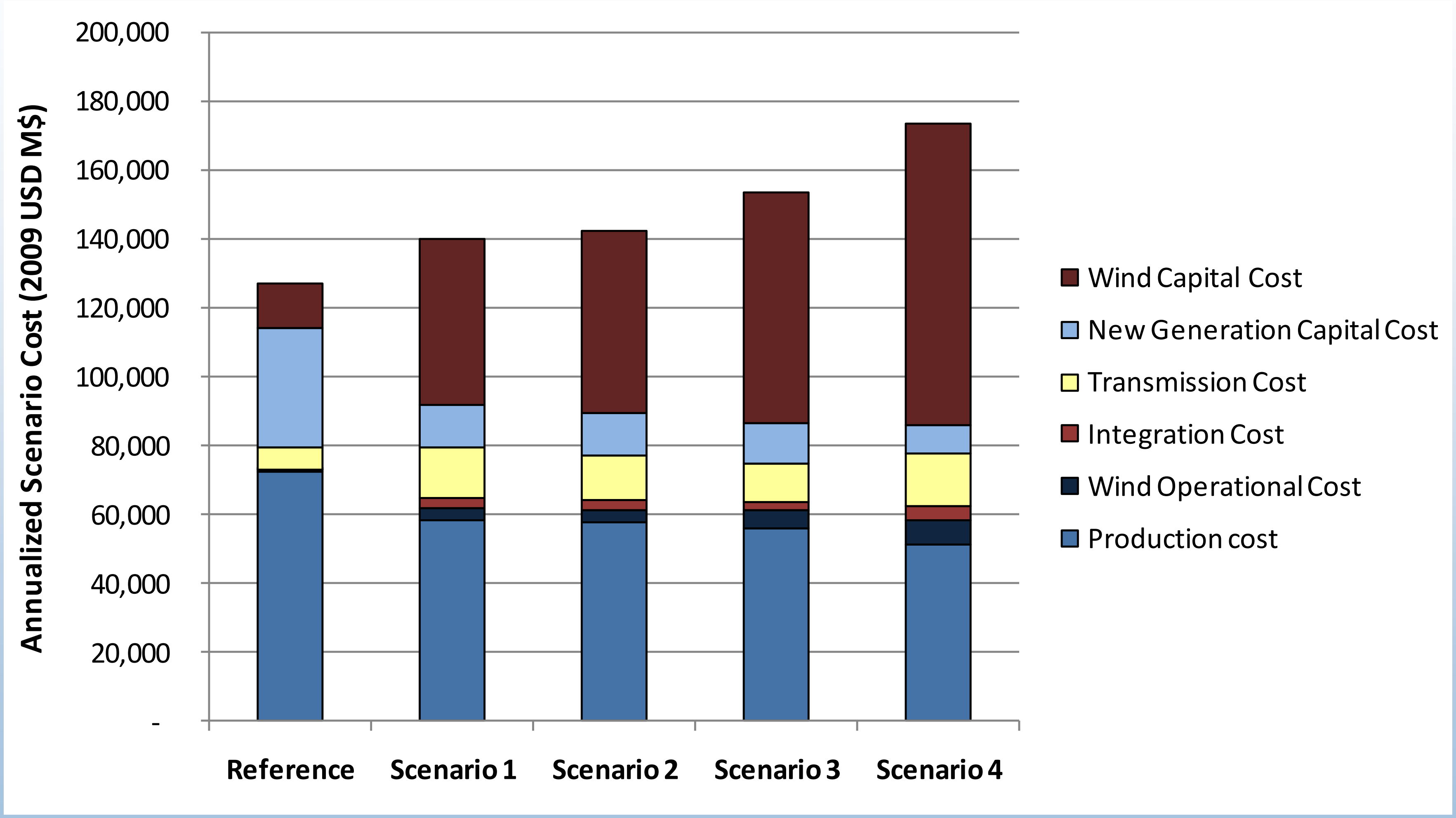
Wind Curtailment by Scenario



	MISO/MAPP	SPP	PJM	ISONE	NYISO	SERCNI	TVASUB	Total Footprint
Reference	1.87%	1.80%	1.98%	1.25%	1.48%	1.06%	1.93%	1.73%
Scenario 1	4.51%	11.57%	3.07%	0.02%	3.63%	0.07%	8.37%	7.02%
Scenario 2	2.69%	12.64%	1.73%	0.56%	10.25%	7.84%	4.34%	6.79%
Scenario 3	2.41%	2.70%	1.81%	7.67%	9.43%	0.47%	0.32%	3.39%
Scenario 4	8.69%	12.46%	8.37%	11.45%	9.56%	6.91%	9.53%	9.77%

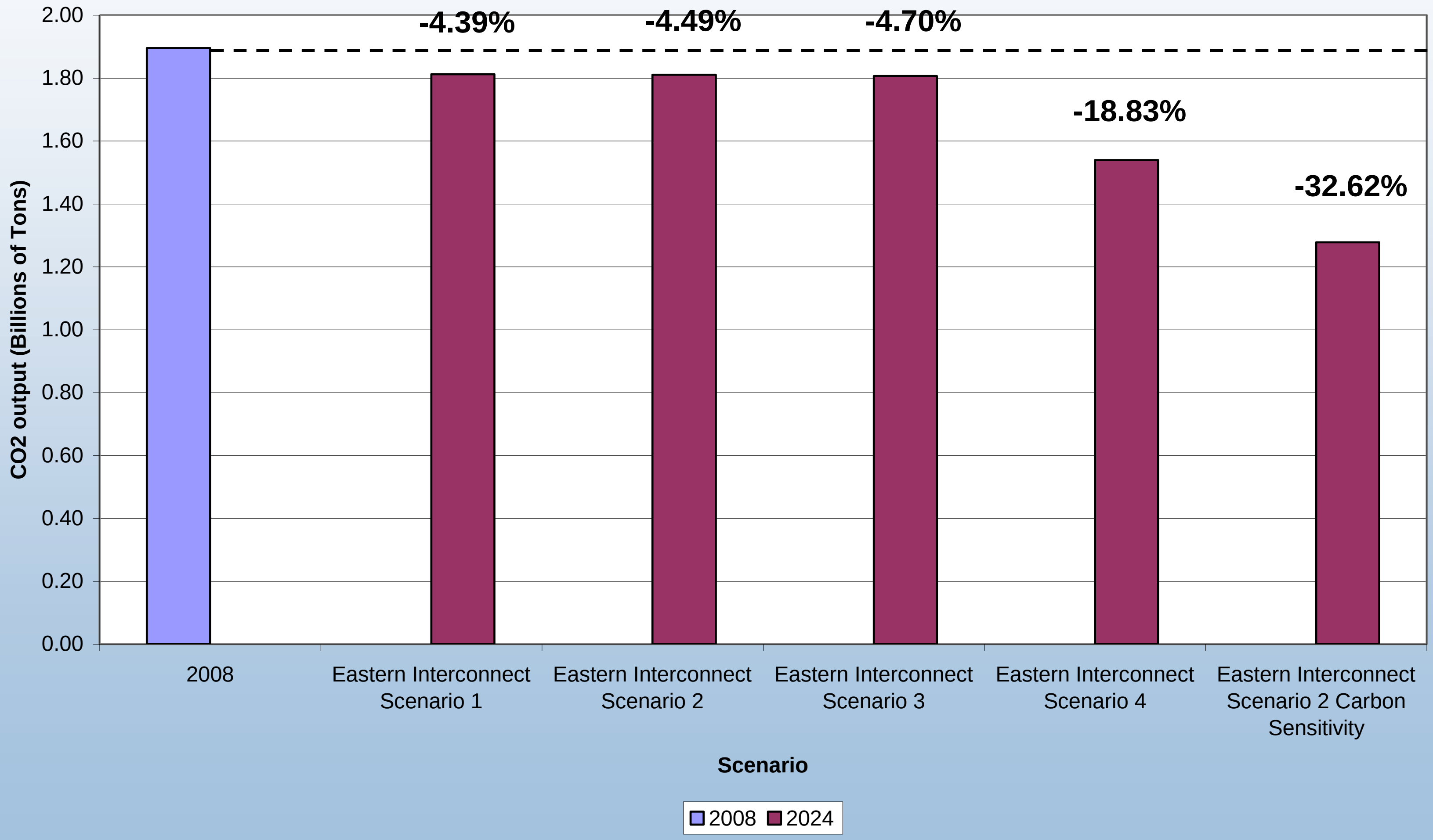
Region

Total Scenario Costs



Carbon Price Sensitivity

Carbon Reductions from 2008 levels



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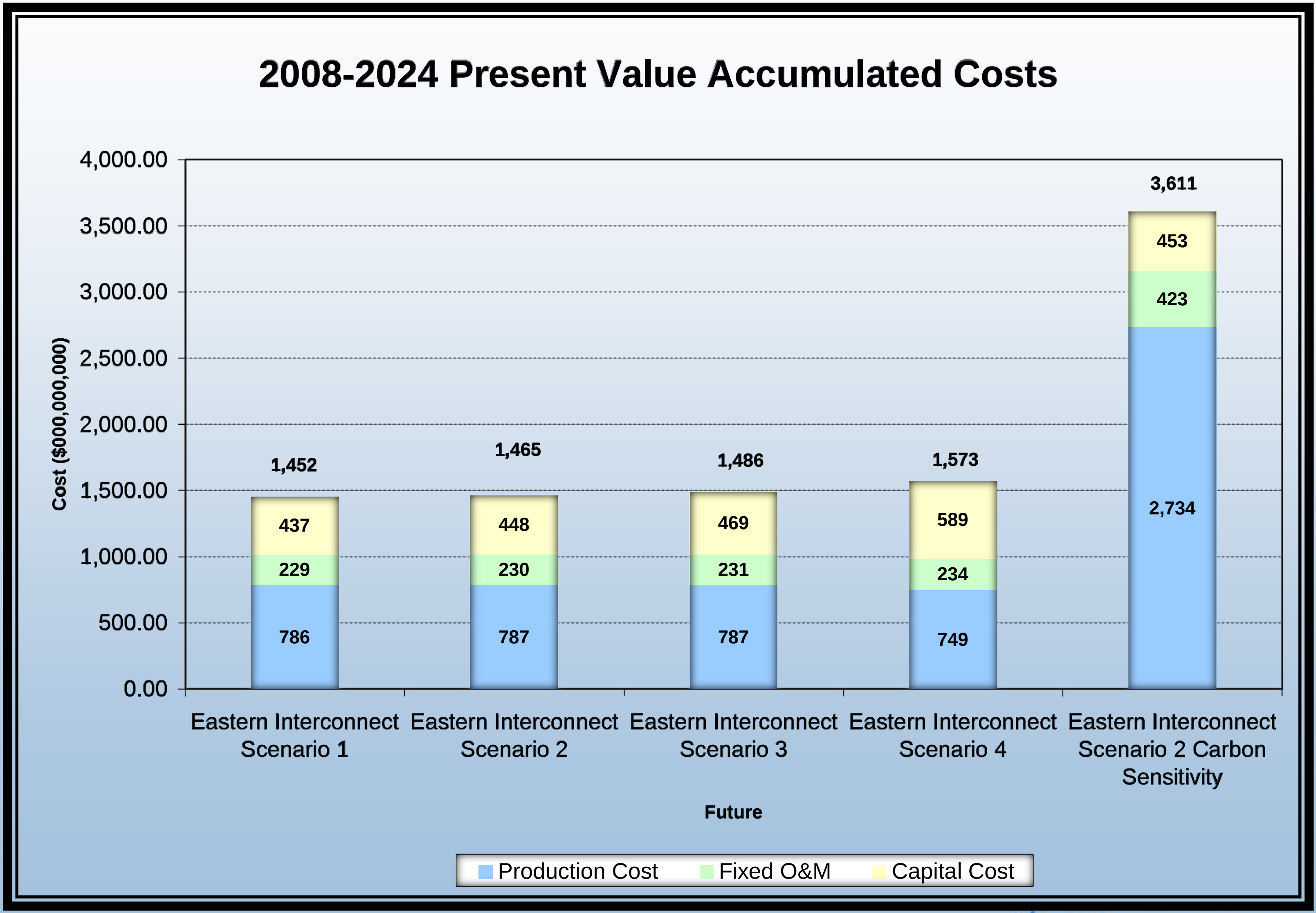
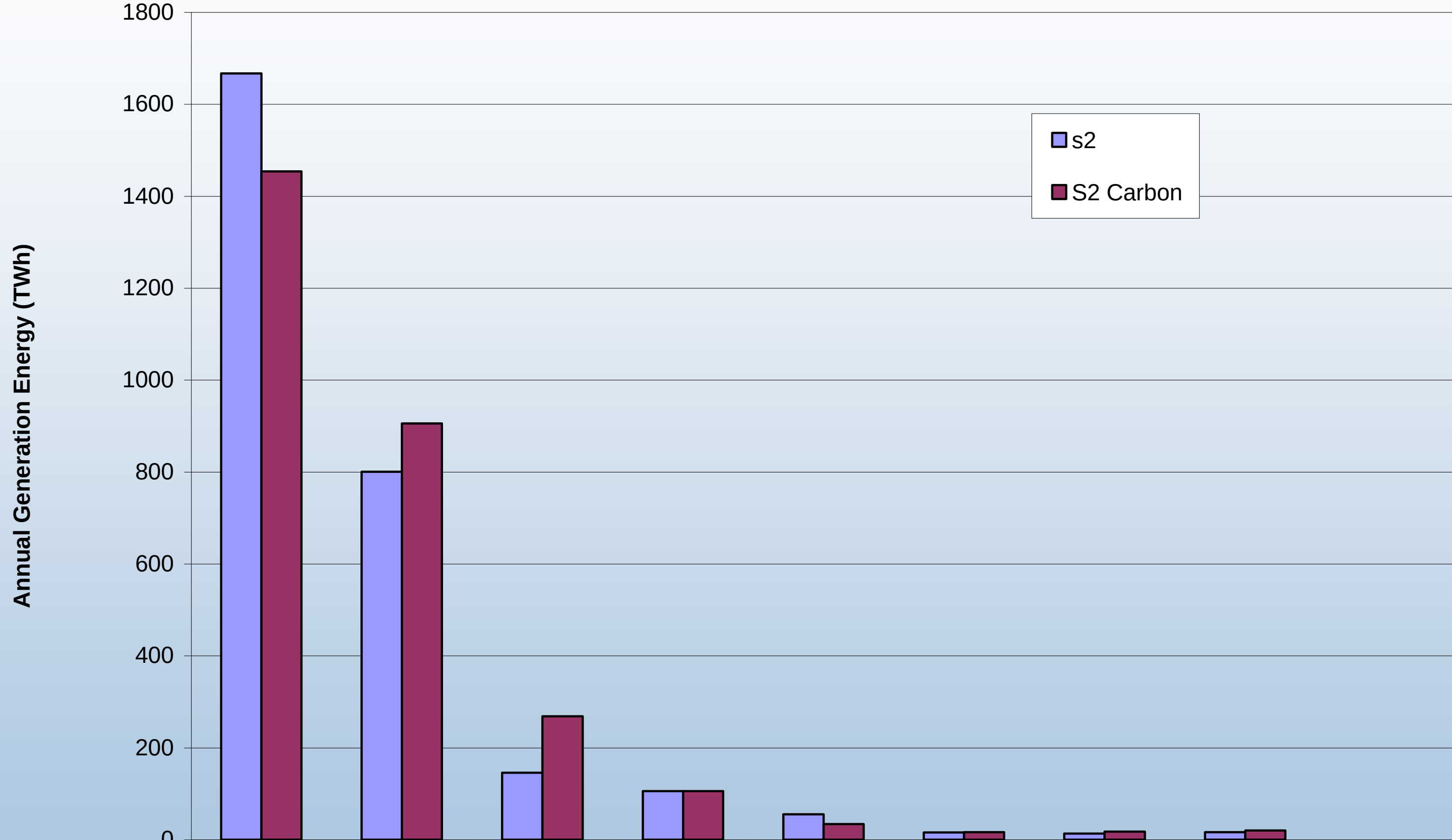
Cost Breakdown for Scenarios



Generation for Carbon Scenario



	ST Coal	Nuclear	Combined Cycle	Hydro	CT Gas	IGCC	ST Gas	Other	Interruptible
s2	1667	801	146	106	55	16	13	16	0
S2 Carbon	1454	906	268	106	34	17	17	20	0

and the conclusion is…

- There are no fundamental technical barriers to the integration of 20% wind energy into the electrical system, but…

- There needs to be a continuing evolution of transmission planning and system operation policy and market development for this to be achieved.

EWITS Conclusions

- High penetrations of wind generation—providing 20% to 30% of the electric energy requirements of Eastern Interconnection—are technically feasible with significant expansion of the transmission infrastructure.
- New transmission will be required for all the future wind scenarios in the Eastern Interconnection, including the reference case. Planning for this transmission, then, is imperative because it takes longer to build new transmission capacity than it does to build new wind plants.
- Without transmission enhancements, substantial curtailment of wind generation would be required for all of the 20% scenarios.
- Interconnection-wide costs for integrating large amounts of wind generation are manageable with large regional operating pools, where benefits of load and wind diversity can be exploited and large numbers of supply resources are efficiently committed and dispatched.

EWITS Conclusions

- Transmission helps reduce the impacts of the variability of the wind, which reduces wind integration costs, increases reliability of the electrical grid, and helps make more efficient use of the available generation resources.
- Although costs for aggressive expansions of the existing grid are significant, they do make up a relatively small piece of the total annualized costs in any of the scenarios studied.
- Wind generation displaces carbon-based fuels, directly reducing carbon dioxide (CO_2) emissions. Emissions continue to decline as more wind is added to the supply picture. Increasing the cost of carbon in the analysis results in higher total production costs.

The results of this study pose some interesting policy and technology development questions

- Could the levels of transmission, including the Reference Case, ever be permitted and built, and if so, what is a realistic time frame?
- Could the level of offshore wind energy infrastructure be ramped up fast enough to meet the aggressive offshore wind assumption in the EWITS scenarios?
- Would a different renewable profile or transmission overlay arise from a bottom-up planning process?
- How can states and the federal government best work together on regional transmission expansion and the massive development of onshore and offshore wind infrastructure?
- What is the best way for regional entities to collaborate to make sure wind is integrated into the bulk electrical grid optimally and reliably ?
- What is the difference between applying a carbon price versus mandating and giving incentives for additional wind?
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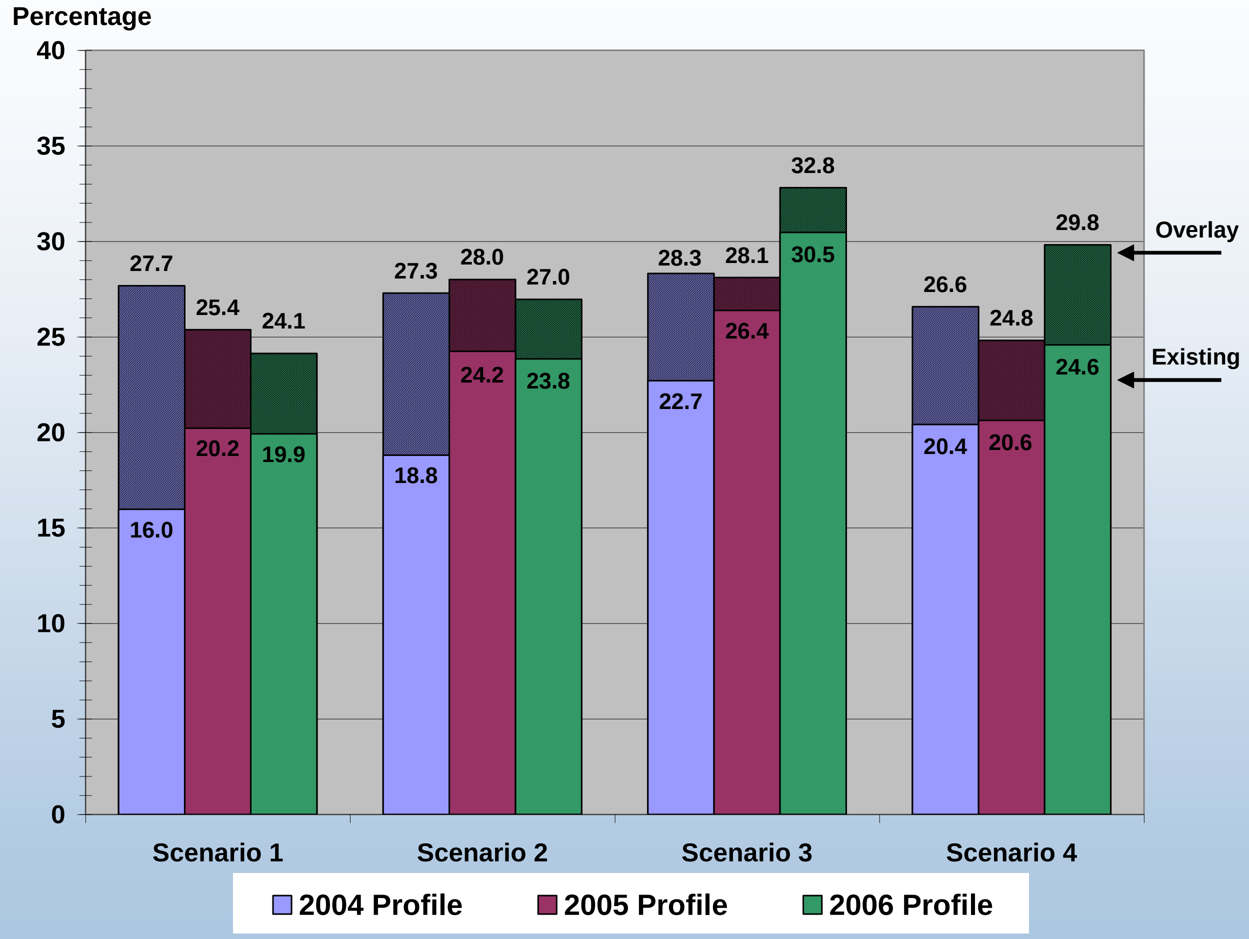
EWITS Schedule & Contacts

- Report going to print next week
- EWITS roll out January 20th , 10 AM, Washington DC.
  - You are all invited!
- Development of Phase II of EWITS in first quarter 2010
- Contact: Dave Corbus at David.Corbus@nrel.gov

An Energy Resource in an Capacity World



LOLE/ELCC results for high penetration scenarios, with and without transmission overlays